

OPEN MEETING AGENDA ITEM

Sun City Water & S

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DANIEL L. BOWERS

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February 7, 2003

Arizona Corporation Commission
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Phoenix, AZ 85007

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Att: Chairman Mark Spitzer

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Dear Sir:

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CAZ

The entire world is running out of water and today we are concerning our selves with watering golf courses.

Tens of thousands of homes are being built in the West Valley, all needing more & more water.

Within ten years that Colorado River water will be sorely needed to supply those and our homes and local business's. Are we going to have dry faucets while golf courses are being watered?

Arizona-American wants the citizens of Sun City, Sun City West and Youngtown to build and maintain a 16+ million dollar pipe line that they will use to sell that water to those same citizens, less than 10% of whom even use the golf courses and Youngtown residents are not even privileged to play on them.

Why should citizens be called upon to pay for capital expenditures by private corporations.

However, money is not the only issue here. Also very important is conservation and wise use of the existing supply. Allowing golf course and lawn irrigation water to spray into the streets and run down the gutters and into little creeks on the courses, all wasted. Watering shrubs, trees and grasses not native to the desert, more waste. We don't have any to waste. I guess only government can stop it and now is the time. Are we allowing too many houses to be built on the aquifer? Probably yes.

Enclosed with this letter is my copy of the September 2002 edition of the National Geographic which contains an excellent 51 page article titled "Earth's Fresh Water". I have many more articles clipped from magazines and newspapers depicting this terrible world predicament I hope you have seen and read most of them also.

Sincerely yours,

A handwritten signature in cursive script that reads "Daniel Bowers". The signature is fluid and elegant, with the first letter of each word being capitalized and prominent.

Daniel L Bowers

NATIONALGEOGRAPHIC.COM • AOL KEYWORD:NATGEO • SEPTEMBER 2002

NATIONAL GEOGRAPHIC



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M E E R K A T S 52
S T A N D T A L L

Rajendra Singh came to the village, bringing with him the promise of water. If ever a place needed moisture, this hamlet in the desiccated Indian state of Rajasthan was it. Always a dry spot, Rajasthan had suffered several years of drought, leaving remote villages like Goratalai with barely enough water to quench the thirst of their inhabitants. Farm plots had shriveled, and men had fled to the cities seeking work, leaving those behind to subsist on roti, corn, and chili paste. Desperate villagers appealed to a local aristocratic family, who in turn contacted Singh, a man renowned across western India for his ability to use traditional methods of capturing monsoon rains to supply water year-round.

Singh arrived in Goratalai on a warm February morning. The sky was robin's egg blue, the same color it had been since August when, everyone recalled, the last rains had fallen. He was greeted by a group of about 50 people waiting in a dirt square under a banyan tree. The men wore loose-fitting cotton pantaloons and turbans of orange, maroon, and white. They were rail-thin, their faces burnished by the sun and distinguished by great mustaches that swept across hollow cheeks. The women were covered from head to toe in vivid orange, gold, and pink clothing, a counterpoint to the parched dun terrain of rock and scrub.

Singh smiled and addressed the villagers.

"How many households do you have?"

"Eighty."

"It's been four years without much rain," interjected a woman. "And we don't have a proper dam to catch the water."

"Do you have any spots where a dam could go?" asked Singh, 43, who has a full head of black hair and a thick beard, both flecked with gray.

"Yes, two spots."

"Will the whole village be willing to work there?"

"Yes," they replied in chorus. The villagers, nearly all of them illiterate, had submitted a petition to Singh asking for help, their names represented by violet thumbprints on a smudged piece of paper.

"I would like to help you," Singh told them, "but the work has to be done by you. You will have to provide one-third of the project

through your labor, and the remaining two-thirds I will arrange."

The villagers clapped, the women broke into song, and the group hiked across the rock-studded hills to a ravine, the women's silver ankle bracelets jangling as they walked. After a few minutes Singh—dressed in a light-golden blouse that fell to his knees and white pants—directed villagers to place stones in a 75-yard line between two hills. "This is an ideal site," he announced. His organization, Tarun Bharat Sangh, would provide the engineering advice and materials. The villagers would supply the sweat equity. The 30-foot-high earthen dam and reservoir, known as a *johad*, could be finished in three months, before the start of the monsoon. If the rains were plentiful, the reservoir would not only provide surface water for drinking and irrigation but would also recharge dry wells as water seeped into the ground.

"You shouldn't get disheartened," Singh told the villagers. "You will not see the results immediately. But soon the dam will begin to raise the water level in your wells."

Ninety minutes after he arrived, Singh was gone, heading to a nearby village that had also requested help building a *johad*. In recent years Singh's *johads* have sprung up all over Rajasthan—an estimated 4,500 dams in about 1,000 villages, all built using local labor and native materials. His movement has caught on, he told me, because it puts control over water in the hands of villagers. "If they feel a *johad* is their own, they will maintain it," said Singh.

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“This is a very sustain-
 able, self-reliant system. I
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 our growing population.”

AMONG the environ-
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 fronting humanity
 in the 21st cen-
 tury—global warming, the
 destruction of rain forests,
 overfishing of the oceans—
 a shortage of fresh water is
 at the top of the list, par-
 ticularly in the developing
 world. Hardly a month passes
 without a new study mak-
 ing another alarming pre-
 diction, further deepening
 concern over what a World
 Bank expert calls the “grim arithmetic of water.”
 Recently the United Nations said that 2.7 bil-
 lion people would face severe water shortages
 by 2025 if consumption continues at current
 rates. Fears about a parched future arise from a
 projected growth of world population from
 more than six billion today to an estimated
 nine billion in 2050. Yet the amount of fresh
 water on Earth is not increasing. Nearly 97 per-
 cent of the planet’s water is salt water in seas
 and oceans. Close to 2 percent of Earth’s water
 is frozen in polar ice sheets and glaciers, and a
 fraction of one percent is available for drink-
 ing, irrigation, and industrial use.

Gloomy water news, however, is not just a
 thing of the future: Today an estimated 1.2 bil-
 lion people drink unclean water, and about 2.5
 billion lack proper toilets or sewerage systems.
 More than five million people die each year
 from water-related diseases such as cholera
 and dysentery. All over the globe farmers and
 municipalities are pumping water out of the
 ground faster than it can be replenished.

Still, as I discovered on a two-month trip to
 Africa, India, and Spain, a host of individuals,
 organizations, and businesses are working



MEXICO CITY'S LEAKY SINK

**Population booming as water pipes crumble, Mexico City must
 truck water to many residents. Once called the Venice of the
 New World for now long-gone lakes and canals, the city has so
 drained its aquifer since 1900 that it has sunk two dozen feet. As
 ground shifts, pipes break; leaks claim nearly a third of its water.**

to solve water’s dismal arithmetic. Some are
 reviving ancient techniques such as rainwater
 harvesting, and others are using 21st-century
 technology. But all have two things in com-
 mon: a desire to obtain maximum efficiency
 from every drop of water and a belief in using
 local solutions and free market incentives in
 their conservation campaigns.

That the planet’s fresh water is consumed
 profligately is beyond doubt, particularly in
 agriculture, which accounts for 70 percent of
 all water use. Getting more out of each drop
 of water is imperative, for as the world’s popu-
 lation increases and the demand for food
 soars, unchecked irrigation poses a serious
 threat to rivers, wetlands, and lakes. China’s
 Yellow River, siphoned off by farmers and
 cities, has failed to reach the sea most years
 during the past decade. In North America not
 only does the Colorado River barely make it to
 the Gulf of California, but last year even the
 Rio Grande dried up before it merged with the
 Gulf of Mexico. In Central Asia the Aral Sea
 shrank by half after the Soviets began divert-
 ing water for cotton and other crops. Else-
 where, countless small rivers have gone dry.

A fraction of one percent of Earth's water is available for

drink

TO SEE WHAT unbridled water consumption has wrought, both good and bad, you need go no farther than the Indian state of Gujarat. Like neighboring Rajasthan, Gujarat is a dry place that has experienced a surge of irrigated agriculture. In the northern part of the state, on a hot spring day, I came across a brick pump house amid flat green fields of wheat, mustard, cumin, and anise. Inside was the electrical system for a 62-horsepower motor that, ten hours a day, pumped a steady column of water from deep underground into a concrete tank through which the water was channeled to nearby fields. One of the pump's owners—70-year-old Nemchandbhai U. Patel—rested on a rope bed in the cool, dusky interior, lulled by the sound of water rushing up from underground aquifers and gurgling into the tank.

Patel stirred as I approached. He explained that the pump was used to irrigate his fields, as well as those of his partners and 50 other farmers who purchase the water. Without it they would have to rely solely on rain, which in an area that receives about 25 inches of precipitation a year—most of it in short summer cloud-bursts—is a highly risky proposition. “Thanks to this well,” said Patel, “we are able to sustain our lives.”

The electric pump that sent water streaming onto Patel's land is the machine that has powered India's green revolution. That agricultural achievement, which has enabled the country to grow enough food for its one billion people, was accomplished because of a huge increase in groundwater pumping. In the mid-fifties fewer than 100,000 motorized pumps were extracting groundwater for Indian agriculture. Today about 20 million are in operation, with the number growing by half a million each year.

But the unregulated use of so much groundwater has come at a high price: With farmers extracting water more quickly than nature can replenish it, aquifers have been depleted to the point that roughly half of India now faces overpumping problems, such as groundwater shortages or the influx of salt water into coastal wells. Many farmers have been forced to abandon wells or keep drilling deeper, raising costs and driving some out of business. In parts of Gujarat the water table has been

dropping as much as 20 feet a year. Four decades ago the water table under Nemchandbhai Patel's fields was at 100 feet; now he must drill 500 feet before he hits water. He keeps deepening his well, but to drill a new one could be prohibitively expensive.

“We think this water may one day be lost to us forever,” said Mohanbhai G. Patel, 67, a nearby well owner whose last name is shared by many in the region. “The water we are now pumping from deep underground has been accumulating for thousands of years. It's like this urn here. If you keep drinking water and never refill it, at some point there will be no more. Unless the government brings in major schemes to recharge these aquifers, we will not survive.”

One reason farmers in India, and throughout the world, have been heedlessly pumping water is that they have paid so little for it. In India the water itself is free, and the government heavily subsidizes the electricity that drives the pumps. Rather than pay for the number of hours a pump runs, farmers pay a low, flat annual rate and pump with abandon.

The overpumping of aquifers, whether for agricultural or municipal use, extends far beyond India. American farmers are withdrawing water from the Ogallala aquifer, which underlies the Great Plains, at an unsustainable rate, with a third of the Texas portion already significantly depleted. The water table under the North China Plain, which produces about half of China's wheat and corn, is steadily dropping. Sandra Postel, a freshwater expert and director of the Massachusetts-based Global Water Policy Project, said that continuing groundwater depletion could reduce China's and India's grain production by 10 to 20 percent in the coming decades.

Two decades ago, as an idealistic young man intent on helping India's rural poor, Rajendra Singh traveled to northwestern Rajasthan, which was suffering water shortages from excessive groundwater extraction. Shortly after he arrived in the impoverished Alwar district, two things became clear to Singh. The first was that managing water wisely was the key to helping drought-prone villages in the region. The second was that farmers were pumping far too much groundwater.

“If that is Singh destroy what solution?”

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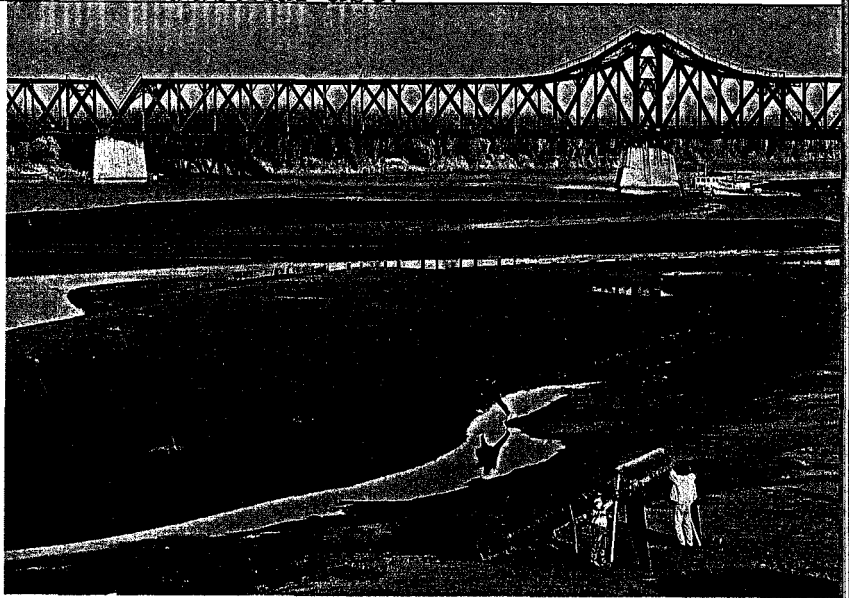
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"If you replenish water, that is a green revolution," Singh told me. "But if you destroy your water capital, what kind of green revolution is that?"

An old villager showed Singh the numerous earthen dams in the district that had fallen into disrepair, their reservoirs filled with silt. They were remnants of a rainwater collection tradition that dated back 5,000 years in India, a system that used the natural terrain to channel and store the brief monsoon downpours for year-round use. But community rainwater collection schemes fell out of favor during British rule and after independence in 1947; their neglect, coupled with over-pumping of groundwater, led to a crisis in villages throughout western India. Singh became consumed with the idea of building johads, gradually helping villagers erect the earthen and stone structures all over Rajasthan.

Today he is perhaps the best known of a large group of people who have revived India's ancient rainwater harvesting techniques, which use not only dams but also underground storage tanks and large concrete-lined reservoirs. Singh's organization—financed by the Ford Foundation, among others—has 45 full-time employees and 230 part-time workers. He spends eight months a year on the road, rarely seeing his wife and son and often sleeping in the backseat of his chauffeur-driven car at night, no small hardship given India's chaotic, treacherous, and polluted highways.

I JOINED SINGH for two days, traveling to a handful of villages where johads had spurred an economic revival. The success of his movement owes much to his personality, which has inspired villagers to follow his lead during the arduous process of building dams, often with their bare hands. His manner



"CHINA'S SORROW" ENTERS A SAD NEW SEASON

Named China's Sorrow for its history of ruinous floods, the Yellow River now barely trickles in its lower reaches—and in recent years has gone dry due largely to heavy irrigation upstream. It's not alone: The once mighty Nile, Ganges, and Colorado Rivers barely reach the sea in dry seasons.

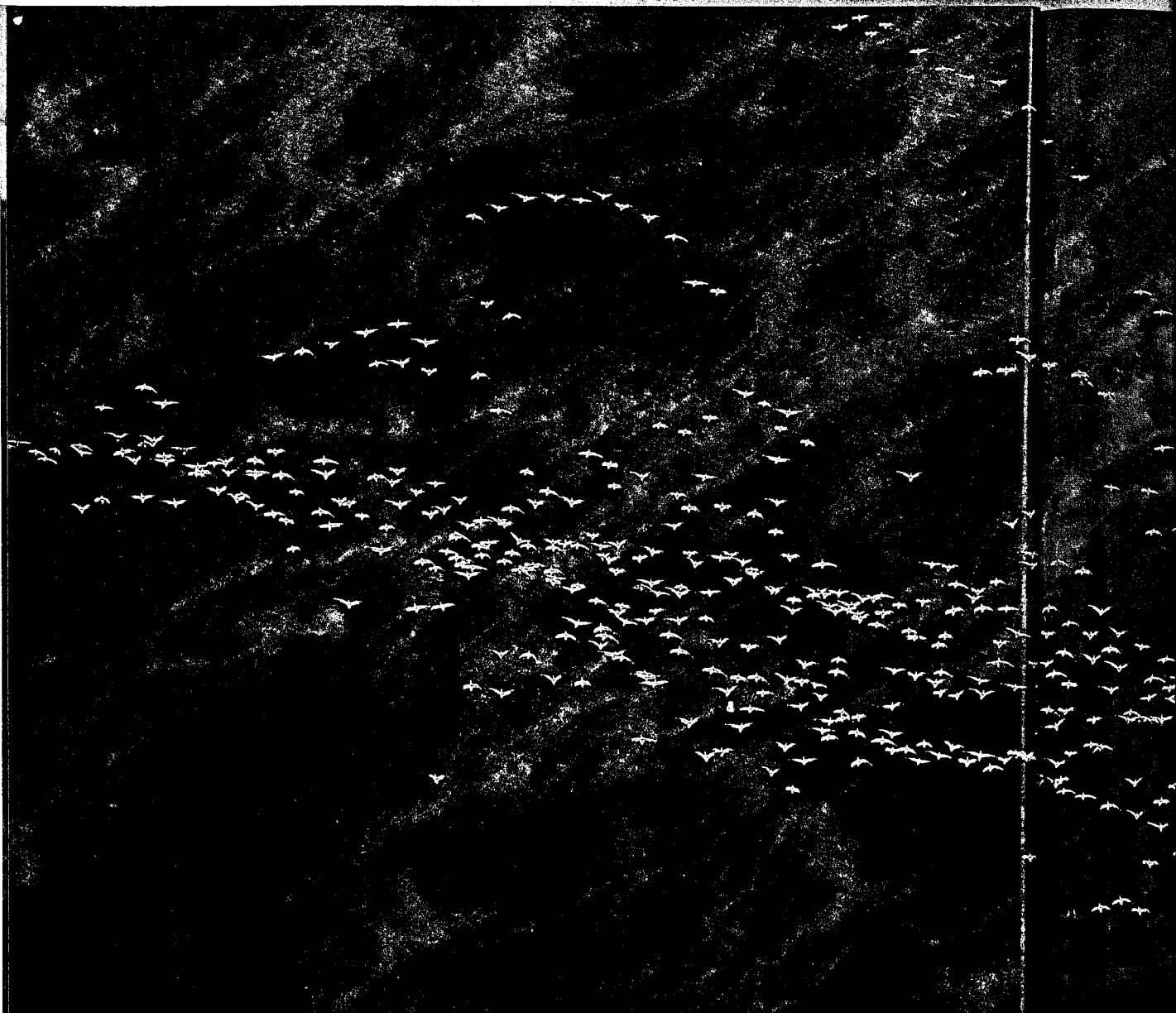
is gentle and unflappable, and he spends hours listening to villagers, sometimes sleeping in their huts and eating their food. In the hamlet of Johdi Ki Dhani, where Singh initiated the construction of three johads, the headman said Singh's quiet, persistent ways overcame the residents' initial skepticism.

"Rajendra Singh used to come as a very simple person," said Suraj Mal Gujur, 45. "He would sit among us and not act like a big shot. He eventually established a very close relationship with us."

One of the villages Singh and I visited was Neemi, situated in dry hills about 20 miles from Rajasthan's capital, Jaipur. Neemi's farmers had pumped many of their wells dry, and some were abandoning the land for work in nearby cities. Singh helped them build several large dams, and by the end of the 1990s the reservoirs began recharging depleted groundwater, catalyzing what villagers describe as a remarkable turnaround in Neemi's fortunes.

Today Neemi is a thriving village in a fertile valley, its fields green with wheat, vegetables, watermelons, and flowers. Not only has migration to the cities

(Continued on page 18)



(Continued from page 11) stopped, but more than 400 farmworkers have also poured into Neemi to cultivate its fruit and vegetables. With more water and fodder available, the number of cattle among Neemi's 122 dairy farmers has increased sharply, quadrupling the village's milk production.

"We knew johads could have an impact," said Radhu Patel, an elderly farmer who was one of Singh's earliest supporters. "But when you're in a car and there's no driver, you can't move the vehicle. Mr. Singh was our driver. Because of his presence we have accomplished all the development you see here."

Singh attributes the growing success of his movement to a basic fact: It encourages local people to build smaller dams and reservoirs in

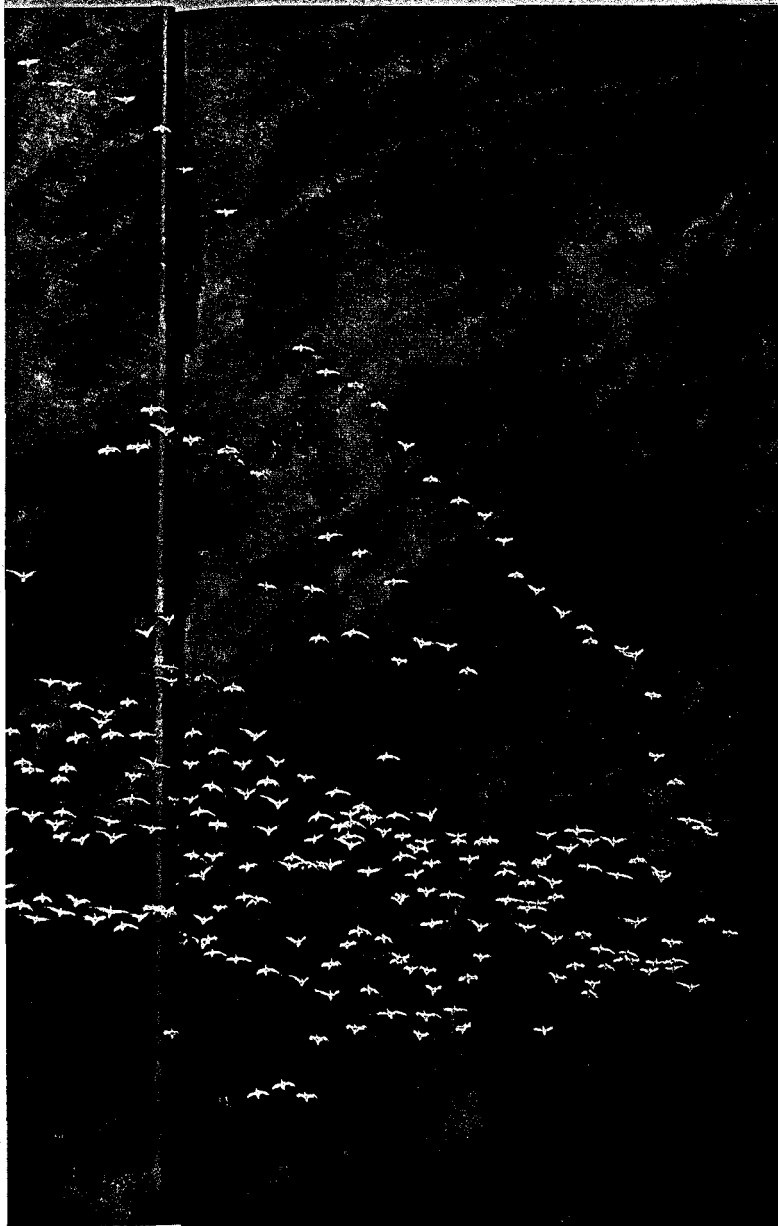
their own backyards, rather than relying on large government-built dams, which often displace residents and transfer water far away.

"This work fulfills the need of the self-reliance of local people," said Singh. "In a small project everyone can participate in decision-making. That's the only real way to improve a community. The community gets employment and has a feeling of ownership and control."

Sunita Narain, director of the nonprofit Center for Science and Environment in New Delhi, said rainwater harvesting is not a panacea and needs to be coupled with conservation measures and, on occasion, the big public works projects Singh abhors. Still, the work of Singh and others has had a profound impact in

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Collision Course

Migratory birds still flock to California's Tule Lake, but the lake is little more than a 10,000-acre, yardstick-deep puddle compared with a century ago, when it reached ten times that size. Most of the water has been diverted for agriculture. In a trend echoed worldwide, 90 percent of California's wetlands have disappeared, and 39 of 67 native fish species are extinct or at risk of extinction. On the nearby Klamath River in Oregon, federal efforts to save three fish species led to a confrontation with farmers last year when officials shut off irrigation water during a drought. The flow has been restored—for now.

India, she said, and is proof of an axiom in the developing world: "Managing water well," said Narain, "is the first step in alleviating poverty."

THE KATUBA REGION, north of the Zambian capital of Lusaka, is not chronically short of water. But it is awash in poverty, and the trick—as Paul Polak knows well—is getting the water from where it lies to farmers' fields, a straightforward task that can bring cash trickling into rural villages.

Polak, a 68-year-old Coloradan fond of wearing orange tennis shoes and suspenders, has spent much of his adult life figuring out how to get water cheaply from point A to point B in the developing world. His own path has not been quite so direct. He was a psychiatrist, who in his extensive travels grew increasingly interested in reducing poverty. Gradually it became clear to Polak that to improve the lives of hundreds of millions of subsistence farmers, water was the starting point.

"You could see how essential water was to alleviating poverty," said Polak. "If you wanted to do anything, you had to start with these small farmers and irrigation. The power to control water is absolutely crucial to them. That fact should shape all development policy."

Polak's shrewd investments in oil and real estate allowed him to spend more time working on improving water delivery to the poor. In 1981 he formed the nonprofit International Development Enterprises (IDE), which has



PROBLEMS: Not Enough, Not Clean Enough



played a major role in disseminating treadle pumps in several countries, such as Bangladesh, which has 1.3 million. This StairMaster-like device enables farmers to transfer shallow groundwater to their fields by stepping up and down on pedals that drive the pump.

Like Rajendra Singh, Polak is convinced that farmers must have a stake in the technology that brings them water. Polak is now the full-time head of IDE, which has a staff of 542 working in seven countries. The organization sells treadle pumps through its own network of local distributors, usually for less than a hundred dollars. Polak's ultimate goal, indicative of his penchant to think big, is to bring treadle pumps or low-cost drip irrigation to 30 million farm families in the developing world.

His efforts in sub-Saharan Africa recently brought him to Zambia. I joined him there as he investigated the irrigation potential of seasonal wetlands called *dambos*, from which water can be easily extracted by a treadle pump. Polak and his staff had estimated that 500,000

farmers living near dambos and other shallow water sources in sub-Saharan Africa could use treadle pumps for irrigation, and what he saw in Zambia did not disabuse him of that notion. Traveling from Lusaka to Victoria Falls in the south, Polak met dozens of farmers using buckets to water their fields. It is a backbreaking, inefficient way to irrigate, and the farmers told Polak they would welcome a treadle pump to reduce the drudgery and increase production.

Evidence of what a treadle pump can do in Africa was on display in the countryside around Katuba, an area of rolling savanna and open woodlands. Most villagers there earn less than a dollar a day, and they live in clusters of grass-roofed mud huts, around which they cultivate small plots of corn, Zambia's staple food. The surrounding hills are dotted with acacias and graceful mopani trees.

Late in the day, with thick white clouds sailing across the sky, Polak stopped at several huts owned by two brothers, Noah and Shadreck Phiri. Short, tautly muscled men in their 30s,

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Relying on a paltry 12 inches of annual rainfall for 60 percent of its water, Jordan builds its dams on hope (left). Most of its rivers are little more than channels for seasonal rains, and if the rains don't come, the reservoirs don't fill. Last year in Matamoros, Mexico, the overused Rio Grande dropped below the city's water intake pipes, but that problem was temporary. With little wastewater treatment, the city's canals (above) fester with sewage and industrial pollution.

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the Phiris were among 2,000 Zambians who have bought IDE treadle pumps over the past five years. Polak greeted the brothers warmly and pulled out a clipboard. With his gray hair and gentle demeanor, he cut a grandfatherly figure, but, as I quickly learned, he is a senior citizen with a workaholic edge. He skipped lunch as he led his entourage around for hours under the scorching midday sun; at night, as he was driven to the next town, Polak would fall asleep in mid-sentence, nodding off during a discourse on Zambian agricultural markets.

Now he launched into a 15-minute interrogation, and it soon emerged that the Phiris had been struggling in their pre-pump days, relying solely on bucket irrigation. The pump, which they bought two years ago, enabled them to expand their fields to about 1.5 acres and grow valuable cash crops, such as baby corn, green beans, and paprika peppers. Their annual income had tripled to \$400 apiece. Now they can feed their children more meat, pay their school fees, and replace the earthen floors

of their huts with concrete. The brothers told Polak they had visions of cultivating more land, hiring laborers, and paying to bring electricity to their homes. "I want to build a very nice house, and put sheet metal on the roof instead of grass," said Shadreck.

The treadle pump, which had a blue metal frame and two-by-fours as pedals, was sitting in the doorway of Noah's hut. It was summer—the rainy season in southern Africa—but rain had been scarce, and Noah was irrigating his fields several times a week. Two of his daughters picked up the pump and carried it to the dambo, which was 150 yards wide and thick with reeds and banana plants. They hooked one end to a pipe that extended from a shallow, open well at the edge of the dambo and connected the other end to a 50-yard piece of black plastic pipe that ran to a field of Chinese cabbage. Noah placed his bare, callused feet on the two-by-fours and began high-stepping in a steady rhythm that he can maintain for the several hours needed to irrigate

In Western Europe and the United States people have long since lo

his fields. Water began gushing onto the light brown earth, splashing the cabbage leaves.

Polak cites estimates that sub-Saharan Africa contains 20 million acres of dambos. Scientists are just beginning to study the impact of irrigation on these wetlands, but he believes that treadle pumps, which withdraw far less water than motorized pumps, do not seriously damage dambos. The potential benefits, he said, are immense.

"Everything that has happened to these guys is because of water," he told me after visiting the Phiris. "It's not that water wasn't available. They just didn't have a good way of getting it to their fields. To me, watching that pump spitting water today, knowing it was adding to that family's productivity... I love it. There's nothing more fulfilling."

IF THE PHIRI BROTHERS are at one end of the spectrum of the world's irrigators, then Kallie Schoeman must surely be somewhere near the other. A sixth-generation Afrikaner, Schoeman presides over South Africa's largest family-owned citrus farm, an operation that covers 4,400 acres in the fertile, heavily irrigated Olifants River Valley. The Schoeman farm has 500,000 citrus trees that annually produce 175 million oranges and lemons for export to 32 countries. At the heart of this flourishing enterprise is a sophisticated irrigation system that points the way to the changes farmers must make as water becomes scarcer and more expensive.

Since joining the family business 27 years ago, Schoeman has helped introduce a succession of irrigation technologies. When he began, the farm simply opened the sluice gates of irrigation canals and flooded the citrus groves, a highly inefficient system still common in the world today. In the 1980s more efficient sprinklers were introduced. Now Schoeman is steadily replacing the sprinklers with super-efficient drip irrigation, which "gives the trees exactly what they need every day," he said, by parceling out small amounts of water to each tree. As Schoeman has used ever more efficient irrigation systems, the farm has quadrupled the production of fruit per acre while actually using a third of the water.

The nerve endings of his present system

are yard-long computerized probes that the irrigation manager, Jaco Burger, places in the soil beneath tidy rows of trees. Every 15 minutes, via solar-powered radio, the probes relay data about soil moisture to the farm's computers. Based on that information and the time of year—the trees need different amounts of water during the different stages of fruit development—Burger adjusts the rate at which water, mixed with fertilizer, flows. Standing in a hundred-acre field, surrounded by about 35,000 young orange trees, I watched as water trickled from a narrow tube into the soil below a sapling—one of three 20-minute feeding pulses the trees would receive that day.

Burger said commercial farmers will have to continue making such technological leaps as water becomes costlier. As he put it, farmers in the Olifants have been paying "next to nothing" for water. But that, and many other aspects of water in South Africa, are beginning to change. In 1998 the government passed the National Water Act, which is designed, in part, to redress the legacy of apartheid by assuring that everyone has equal access to water. The law looks at river basins as ecological systems, requiring that basic human needs, such as clean drinking water, and basic environmental needs, such as maintaining stream flows, be met before giving water to industry and agriculture.

"We know agriculture won't get more water," said Schoeman. "We will get less, it will become more expensive, and we will have to use it more efficiently."

Another South African with an obsessive desire to make the most of every drop of water is Neil Macleod, the man in charge of providing water and sewerage services to roughly three million people in Durban. A plain-spoken, unassuming civil engineer of 50 with a brush mustache, Macleod has drastically reduced waste in the city's water system while simultaneously improving water delivery to the urban poor.

Taking over as executive director of Durban Metro Water Services in 1992, two years before the end of apartheid, Macleod encountered an abysmal situation. Durban had one million people living in the city proper and another 1.5 million people, almost all black, who had

moved into townships where living conditions were just as bad. Macleod determined that one of the region's biggest problems was the leaking of water pipes, toilets, and showers. Of the 100,000 people who were two-thirds black, a combination of 500,000, 50 percent of the population, was living in informal settlements, and other waste

"People who don't have water for water, or toilet water, or water for the garden," recalled Macleod. "They inherited the land and built their own streets. Durban was growing, and we'd have

Macleod to tame the city by repairing and upgrading the infrastructure on residential areas with two-story houses and full showers. The poor were the poor, and Macleod wanted to get the water to each household.

Water in Durban is not as expensive as in the United States. By cutting waste, the most expensive measure, Macleod has saved 100 million dollars. Plans to build new dams and sewers, a 300,000-unit

Around the world, water programs have produced results. U.

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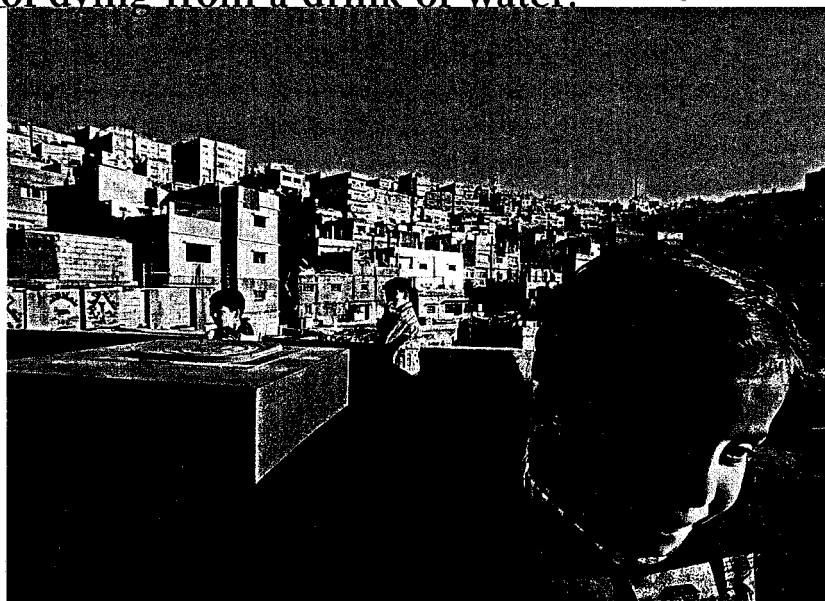
moved into shantytowns or were living in housing projects just outside the city. Macleod and his engineers determined that 42 percent of the region's water was being wasted because of broken water pipes and mains, leaky toilets, and faulty plumbing. Of particular concern were two large districts, with a combined population of 500,000, where up to 87 percent of the water was being lost due to leaks and other wastage.

"People were not paying for water, and if a shower or toilet was broken, it just ran," recalled Macleod. "We inherited 700 reported leaks and bursts. The water literally just ran down the streets. Demand for water was growing 4 percent a year, and we thought we'd have to build another dam by 2000."

Macleod embarked on a crash program to tame the colossal losses. His crews began repairing and replacing mains. They put meters on residences, replaced four-gallon flush toilets with two-gallon models, and retrofitted wasteful showerheads and water taps. To ensure that the poor would receive a basic supply of water, Macleod installed tanks in homes and apartments to provide 50 gallons of water a day free to each household.

Water consumption in metropolitan Durban is now less than it was in 1996, even as 800,000 more people have received service. By cutting water use—daily consumption in the most wasteful districts has been reduced by more than half—Durban's conservation measures paid for themselves within a year. Plans to build a costly new dam have been shelved, and Macleod is confident that no new dams will be needed in the coming decades, despite the expected addition of about 300,000 users.

Around the world other water conservation programs have also achieved impressive results. U.S. cities such as Boston, Seattle, and



MAKING DO IN AN ARID LAND

In summer the taps run only a day or two a week in Amman, Jordan, so residents have to store water in rooftop tanks. The rations will likely get even tighter in years to come: Jordan's population is on track to double within a quarter century.

Albuquerque have reduced demand 20 to 25 percent in part by repairing aging infrastructure and retrofitting plumbing fixtures in homes. Indeed, per capita indoor water use in the U.S. has dropped since 1980. Outdoor use, however, has risen, probably because so many people have installed automatic lawn sprinkler systems. Today, the average American uses 101 gallons of water a day—more than 15 times that used by many people in developing countries.

IN DURBAN, Macleod has now turned to water recycling. With the region's water supplier increasing prices, he decided to take about 10 million of the 125 million gallons of wastewater the city treated daily and use it again, piping it to industries nearby. The French firm Vivendi, one of a growing number of companies involved in water management, built a sophisticated treatment facility next to one of Durban's wastewater plants. Operators of a nearby paper mill and refinery are satisfied because they pay almost half price for the recycled water, and Macleod is pleased because the recycling has cut metropolitan water demand by about 5 percent.



On a steamy afternoon Macleod took me to the plant, where I watched wastewater turned into clean water in just 12 hours as it passed through sand and carbon filters, was treated with ozone, and dosed with chlorine. I finished the tour on the roof of the Vivendi facility, where glasses of water were arrayed on a table. I took several sips and could not discern a difference between the municipal drinking water and the treated wastewater. Though intended for industrial use, the recycled water I sampled was pure enough for drinking.

The sweet taste of the treated wastewater was a taste of the future, for in the years to come water recycling will likely become increasingly common. Indeed, in the neighboring desert nation of Namibia, Vivendi is

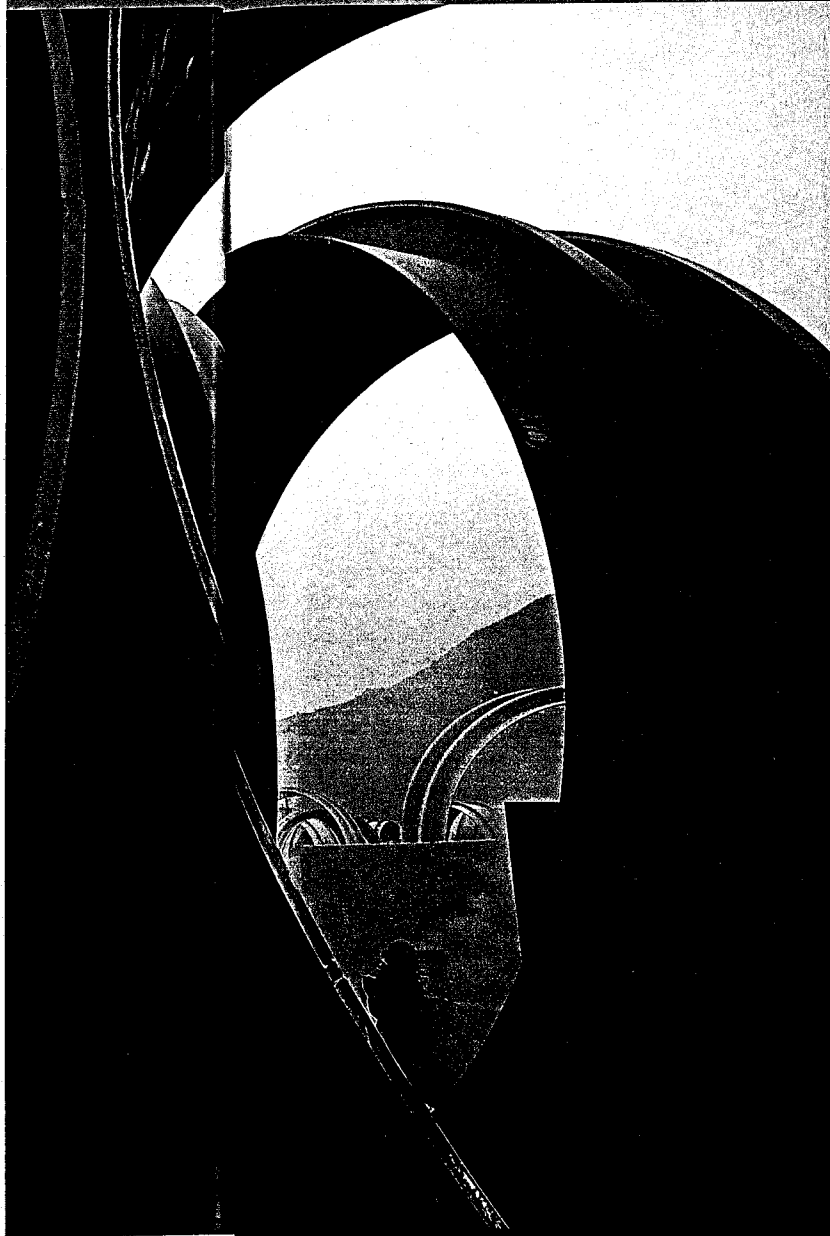
a partner in a plant that turns wastewater directly into drinking water for the capital, Windhoek, refining the water even one step further than Durban's recycling operation. Windhoek's wastewater-to-drinking water plant is the only such facility in the world, but Stephen McCarley, the general manager of Vivendi's Durban operation, is confident it won't be the last.

"As water goes up in price, the opportunities to do this kind of treatment will grow," said McCarley, my guide on the tour of the Durban plant. "From the technological point of view, you can do anything with water. As the resource is more constrained, people will have to get used to recycling."

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Macleod chimed in, "Go to many areas of the world, and they're drinking far worse water than this."

MACLEOD would not have to go far. His own province of KwaZulu-Natal was fighting a cholera outbreak, proof that post-apartheid South Africa—despite its water pioneers and progressive water legislation—still has a huge gap between blacks and whites. The South African government has succeeded in bringing safe drinking water to millions of its citizens in recent years, but about 7 million of the country's 44 million people still lack access to clean water within 200 yards of their homes. Drinking contaminated water, often from streams, was behind the most recent outbreak, which has killed 289 people in KwaZulu-Natal and infected 120,000 others since August 2000. Those deaths were among the 18,000 that occur in South Africa annually from diarrhea-related ailments, most of which are waterborne.

The outbreak was centered in the hilly, picturesque Ladysmith region, where whites typically have water and sewerage systems, but where 85 percent of blacks lack proper sanitation and 60 percent do not have access to the South African government's minimum recommended quantity of clean water: 25 liters (6.6 gallons) per person per day.

I visited rural health clinics where patients lay under canvas tents, receiving rehydration fluid, intravenously and orally, to counteract

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The Dam Dilemma

In Tehri, India, pipes that will feed hydro-electric turbines hint at the scale of what will soon be one of the world's tallest dams. The reach and benefits of dams are enormous: The world's 45,000 large dams catch 14 percent of all precipitation runoff, provide water for up to 40 percent of irrigated land, and give some 65 countries more than half their electricity. But the costs are also enormous. In India alone, up to 38 million people have been displaced by large-scale dams. This group of Tehri women, forced to leave their homes, protest the compensation the government has offered them.



SOLUTIONS: Use Less, Use It Again



Low on water in parks with industry, of urban Santiago, Chile

the cholera infection, which can cause rapid death from diarrhea-induced dehydration.

In the Mhlumayo area, along a feeble stream called Impundu, I met the family of one of the victims, a 59-year-old farmer named Mkhanyiswa Sithole. I found his wife and several of their eight children amid a cluster of huts perched on a hillside. Khithiza Sithole, 53, was a regal woman in a long, blue mourning dress. She sat on a grass mat and recounted how her husband fell ill around 4 a.m. on November 26, 2001.

"The diarrhea started, and he was crying about the pain in his stomach," said Mrs. Sithole. "He was vomiting and having bad cramps. He kept crying out."

Shortly after noon the family drove him to a rural clinic, where he was given intravenous fluids. His condition worsened, however, and he was transferred by ambulance to Ladysmith Hospital. There, despite continued treatment, he died around 11 p.m., less than 24 hours after falling ill. The family suspects that he may have contracted cholera after drinking

directly from the Impundu. Several other people in the village also died.

"I am struggling after his death," said Mrs. Sithole, whose family survives by virtue of a small vegetable plot, cattle, and goats.

A few yards away, in the middle of a corral made from woven saplings, was Mr. Sithole's grave. Following Zulu custom, he was buried in a place of honor, among the family's livestock, and covered with a mound of rocks.

IN WESTERN EUROPE and the United States people have long since lost their fear of dying from a drink of water. Nevertheless, water use there poses an altogether different threat, this one to nature itself.

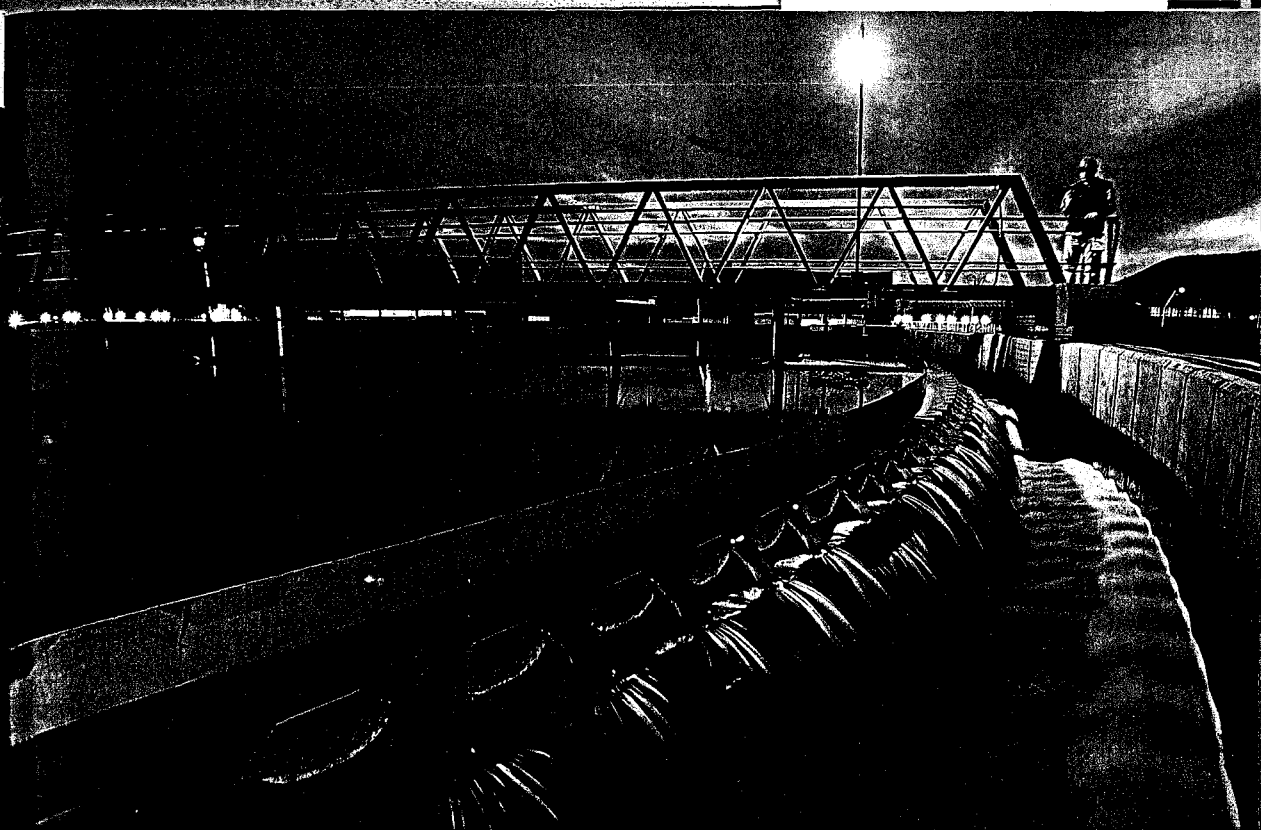
In the Castile La Mancha region of south-central Spain, a 74-year-old former fisherman, Julio Escudero, has seen one of the country's prized wetlands altered beyond recognition. Escudero was born on the banks of Las Tablas de Daimiel, a freshwater marsh at the heart of a sprawling, 60,000-acre mosaic of wetlands

in La Mancha commun that harvest Escudero Guadiana called Los Ojos undergrowth limpid water

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Low on water but not options, St. Petersburg, Florida, has been a conservation pioneer, stocking parks with drought-tolerant plants (left) and recycling its wastewater. Used for irrigation and industry, treated wastewater may one day meet a fifth of the city's needs. Worldwide, two-thirds of urban wastewater doesn't even get treated, much less recycled, but that could change. Santiago, Chile, which just opened a treatment plant (above), will treat all its wastewater by 2009.

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in La Mancha. He was part of a small fishing community of 300 families around Daimiel that harvested primarily carp and crayfish. Escudero sometimes fished on the picturesque Guadiana River and fondly recalls an area called Los Ojos—"the eyes"—where large, underground springs bubbled up into the limpid waterway.

"We could see all the water rising from the bottom in big columns," said Escudero. "I would sit in my boat six or seven meters away and just watch the water coming up. Now it looks like the moon."

Los Ojos is no more: The underwater springs dried up in 1984. That stretch of the Guadiana—a six-mile portion above Daimiel—also has disappeared. Where there was once a gentle, percolating river, 30 yards wide, there now are a road, fields of grain, and rocky portions of riverbed. The 60,000 acres of original wetlands, superb habitat for cranes and waterfowl, have shrunk to a core area of about 14,000 acres.

What happened? An onslaught of irrigated

agriculture. La Mancha has witnessed an explosion of well digging in the past 40 years that has lowered the water table and reduced streamflows. The number of irrigated acres—farmers grow alfalfa, barley, corn, wheat, and sugar beets, among other crops—has soared from 60,000 in 1960 to 500,000 today, and the number of wells has grown from 1,500 to an official count of 21,000. Some experts say the total number, including illegal wells, could surpass 50,000.

"As long as you have so many wells sucking out the groundwater, Las Tablas won't come back," said Escudero, the last commercial fisherman to work in Las Tablas de Daimiel. "I see no solution. I see a cadaver."

Spain is now at a crossroads. Like another semi-arid region, southern California, this Mediterranean country has built dams—about 1,200 major ones—and piped water long distances to supply farms and municipalities. Now a new National Hydrological Plan calls for transferring nearly 1.4 billion cubic yards of

water a year from the Ebro River in the north to burgeoning regions along the Mediterranean coast. The plan has stirred controversy, with a growing number of opponents questioning the cost, economic and environmental, of such massive schemes. The government says the multibillion-dollar project is necessary to halt the overexploitation of southern aquifers. But environmentalists contend that the Ebro has already lost half its flow because of irrigation and dams and will shrink even further, accelerating the decline of the Ebro Delta, a prime Mediterranean fish nursery and vital bird habitat.

Spanish environmentalists say it is time to stop draining the country's wetlands and to curtail agricultural subsidies that underwrite the cultivation of irrigated crops, encouraging profligate water use. Spain's greatest wetland—Doñana on the Atlantic coast, home to half a million overwintering birds and a stopover for six million migratory birds—has seen its natural marshlands cut from about 370,000 acres to 75,000 because of agricultural development and water engineering projects. (Despite such losses, Doñana still attracts large numbers of flamingos, white storks, glossy ibises, greylag geese, and other waterfowl because the wetlands were converted to flooded rice fields or aquaculture ponds.) The government and conservation groups have now embarked on a major reengineering program—similar to an eight-billion-dollar plan to restore water flows in the Florida Everglades—that will revive some of Doñana's marshes.

"Water is controlled by the strawberry growers, the rice growers, the tourism hotels," said Beltrán de Ceballos, head of the Doñana Foundation, a conservation group that has begun restoring wetlands. "It's controlled by everyone, but what doesn't get taken into account is water for the birds."

THIS CENTURY many countries will face the dilemma being confronted by the people of Spain: how to balance human needs with the requirements of natural systems that are vital to sustain life on Earth. Some are hoping that new technologies, such as the desalination of seawater, will solve the problems faced by a water-stressed world. Yet only two-tenths of

WATER BLUES OR A BLUE REVOLUTION?

Water is momentarily plentiful for a boy in the gush of a Calcutta well, but as he grows into a man, India's water situation—and the world's—will likely go from bad to worse. Another two billion people will need food and water by 2025. Will the planet have enough water? That depends on how wisely it's used.

one percent of the water people use today is desalinated, and most of that is produced in desert kingdoms and island nations. Desalination is sure to become more common—plants are now under construction in southern California and Florida—but some experts remain skeptical that the process will become widespread, because of its cost.

"There is a kind of a silver bullet belief about desalination," said Sandra Postel of the Global Water Policy Project. "But the fact is, water conservation is where the big gains are to be made."

Indeed, during my travels I came away most impressed with the ingenuity of people like Rajendra Singh and Neil Macleod. The choice of heeding or ignoring such innovators is a stark one, as I saw in western India. In Gujarat's largest city, Ahmadabad, the Sabarmati River once flowed perennially through the heart of town. Today, due to the construction of a large dam and overpumping of the region's aquifers, the river only runs during the monsoon floods in summer. The rest of the time the Sabarmati is what I saw last February—a dry, dust-shrouded scar inhabited by tens of thousands of people living in fetid squatters' shacks.

A few hundred miles to the north, in Rajasthan's Sariska Tiger Reserve, is another vision. There, in an arid mountain valley where residents once walked two miles to fetch water, Rajendra Singh has helped villagers construct several low dams. Where once there was a dry creek bed, now there are reservoirs. Lined by palms and looking very much like an oasis, their waters offer people what they have lacked for decades—a cool drink, close at hand. □

MORE ON OUR WEBSITE

Go behind the scenes in the story of water with Fen Montaigne and Peter Essick. Find zoom-in images, links, and research sources at nationalgeographic.com/ngm/0209.

COLORADO

Ugly drought could sink Dredge floating eatery

Associated Press

BRECKENRIDGE, Colo.

Colorado's worst drought on record has left a \$3 million floating restaurant-bar, a replica of a gold dredge from the frontier days, sitting partly aground and in danger of breaking up.

Normally, the pond it floats on in this ski town's tourist center is 40 feet deep, filled by water released from the city's reservoir. But because of the drought, Breckenridge has cut back on releases. As a result, the water level has dropped enough that one end of the Dredge restaurant is sitting on the pond's bottom.

Steven Rockne knew his family's restaurant was in trouble when it listed so much that balls on the pool table rolled on their own into one of the pockets.

"Our guests began talking about holding a Titanic party," said Carol



Robert Weller/Associated Press

A floating restaurant-bar in Breckenridge is in danger of breaking up amid Colorado's drought.

Rockne, his mother.

After the Rocknes appealed for help, the city released water into the pond to support the 1,000-ton restaurant. But city officials say they don't have enough water to keep the Dredge afloat until spring.